Electronic Version

Stylesheet Version v1.1.1

Claims

[c1] 1.A method for performing an electromigration check for conductors with alternating current flow adjacent to conductors with direct current flow in an integrated circuit comprising:

determining resistances R_{WIRE} and a capacitance matrix C for the integrated circuit;

converting the capacitance matrix C into a thermal conductance matrix G;

determining temperature differences ΔT_{ni} between conductors from thermal conductances G_{thi} of the thermal conductance matrix G;

approximating power flow P_n into conductors with direct current flow due to adjacent conductors with alternating current flow in the integrated circuit from the temperature differences ΔT_{ni} between conductors and the thermal conductances G_{thi};

determining a power limit as a function of the maximum temperature difference ΔT_{MAX} that ensures reliability of the integrated circuit; and

performing the electromigration check by limiting power generated in the conductors with alternating current flow to less than the power limit.

[c2] 2.The method of claim 1, wherein the thermal conductance matrix G is determined from the product of the capacitance matrix C and a scalar factor F and the scalar factor is given by a ratio of thermal conductivity κ to permittivity ϵ.

[c3] 3.The method of claim 1, wherein the power limit is given by the product of scalar factor F, the total capacitance C_{ntot} and the maximum temperature difference ΔT_{MAX}.

[c4] 4.The method of claim 1, wherein the I_{RMS} value is determined by the expression: C_{load}*V_{dd}*frequency*Switching factor.

[c5] 5.The method of claim 1, wherein the thermal conductances G_{thi} are inputs for a circuit simulator that determines temperature differences between conductors ΔT_{ni} as outputs of the circuit simulator.

[c6] 6.The method of claim 1, wherein the capacitance matrix C and resistances R_{WIRE} are determined by using simulation and analysis tools that at least include capacitance/ resistance extraction capabilities.

[c7] 7.A method for performing an electromigration check for conductors with alternating current flow adjacent to con-

ductors with direct current flow comprising:

determining resistances R_{WIRE} and capacitances C_{ni} for conductors with alternating current flow and conductors with direct current flow;

converting the capacitances C_{ni} into thermal conductances G_{thi};

determining temperature differences ΔT_{ni} between conductors from the thermal conductances G_{thi};

approximating power flow P_n into conductors with direct current flow due to adjacent conductors with alternating current flow from the temperature differences ΔT_{ni} between conductors and thermal conductances G_{thi};

determining a power limit as a function of a maximum temperature difference ΔT_{MAX} for the conductors that ensures reliability of the conductor; and

performing the electromigration check by limiting power generated in the conductors with alternating current flow to less than the power limit.

[c8] 8.The method of claim 7, wherein the thermal conductances G_{thi} are determined from the product of the capacitances C_{ni} and a factor F and the scalar factor F is given by a ratio of thermal conductivity κ to permittivity ϵ.

[c9] 9.The method of claim 7, wherein the power limit is given by the product of scalar factor F, the total capacitance C_{ntot} and the maximum temperature difference ΔT_{MAX}.

[c10] 10.The method of claim 7, wherein the I_{RMS} value is determined by the expression:

C_{load}*V_{dd}*frequency*Switching factor.

[c11] 11.The method of claim 7, wherein the thermal conductances G_{thi} are inputs for a circuit simulator that determines temperature differences between conductors ΔT_{ni} as outputs of the circuit simulator.

[c12] 12.The method of claim 7, wherein the capacitances C_{ni} and resistances R_{WIRE} are determined by using simulation and analysis tools that at least include capacitance/resistance extraction capabilities.

[c13] 13.A method for performing a check of local heating in a device comprising:

determining resistances R_{WIRE} and at least one of capacitances C_{ni} and a capacitance matrix C for the device;

determining thermal conductances G_{thi} from the at least one of capacitances C_{ni} and a capacitance matrix C;

setting a maximum temperature difference ΔT_{MAX} in accordance with electromigration requirements; determining a power limit $F * C_{ntot} * \Delta T_{MAX}$ as a function of the maximum temperature difference ΔT_{MAX};

checking each interconnect conductor with an alternating current flow to determine if power generated $I_{RMS} * R_{WIRE}{}^2$ is less than the power limit $F * C_{ntot} * \Delta T_{MAX}$;

indicating no local heating problem with an interconnect conductor when power generated $I_{RMS} * R_{WIRE}{}^2$ is less than the power limit $F * C_{ntot} * \Delta T_{MAX}$;

indicating a local heating problem exist with current interconnect conductor when the power generated $I_{RMS} * R_{WIRE}{}^2$ is equal to or greater than power limit $F * C_{ntot} * \Delta T_{MAX}$ and taking corrective action to reduce the power generated $I_{RMS} * R_{WIRE}{}^2$; and

continuing to check each interconnect conductor with alternating current flow until all interconnect conductors have a value for power generated $I_{RMS} * R_{WIRE}{}^2$ less than the power limit $F * C_{ntot} * \Delta T_{MAX}$.

[c14] 14.The method of claim 13, wherein the thermal conductances G_{thi} are determined from the product of the capacitances C_{ni} and a factor F and the scalar factor F is given by a ratio of thermal conductivity κ to permittivity ϵ.

[c15] 15.The method of claim 13, wherein the power limit is given by the product of scalar factor F, the total capacitance C_{ntot} and the maximum temperature difference ΔT_{MAX}.

[c16] 16.The method of claim 13, wherein the I_{RMS} value is determined by the expression:

C_{load}*V_{dd}*frequency*Switching factor.

[c17] 17.The method of claim 13, wherein thermal conductances G_{thi} are inputs for a circuit simulator that determines temperature differences ΔT_{ni} as outputs of the circuit simulator.

[c18] 18.The method of claim 13, wherein the capacitances C_{ni} and resistances R_{WIRE} are determined by using simulation and analysis tools that at least include capacitance/resistance extraction capabilities.

[c19] 19.A computer-readable medium having a plurality of computer executable
instructions for causing a computer to perform an electromigration check for conductors with alternating current flow adjacent to conductors with direct current flow in an integrated circuit, the computer executable instructions comprising:

determining resistances R_{WIRE} and a capacitance ma-

trix C for the integrated circuit;

converting the capacitance matrix C into a thermal conductance matrix G;

determining temperature differences ΔT_{ni} between conductors from thermal conductances G_{thi} of the thermal conductance matrix G;

approximating power flow P_n into conductors with direct current flow due to adjacent conductors with alternating current flow in the integrated circuit from the temperature differences ΔT_{ni} between conductors and the thermal conductances G_{thi};

determining a power limit as a function of the maximum temperature difference ΔT_{MAX} that ensures reliability of the integrated circuit; and

perfoming the electromigration check by limiting power generated in the conductors with alternating current flow to less than the power limit.

[c20] 20.The method of claim 19, wherein the thermal conductance matrix G is determined from the product of the capacitance matrix C and a scalar factor F and the scalar factor is given by a ratio of thermal conductivity κ to permittivity ϵ.

[c21] 21.The method of claim 1, wherein the power limit is given by the product of scalar factor F, the total capacitance C_{ntot} and the maximum temperature difference ΔT

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[c22] 22.The method of claim 1, wherein the I_{RMS} value is determined by the expression:

C_{load}*V_{dd}*frequency*Switching factor.

[c23] The method of claim 1, wherein the thermal conductances G_{thi} are inputs for a circuit simulator that determines temperature differences between conductors ΔT_{ni} as outputs of the circuit simulator.